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Electron collision frequency in Martian ionosphere

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The results for F_2 region (Bradbury Layer) collision frequency of the Martian atmosphere are presented. It is observed that for this layer, the collision frequency of electrons with neutral constituents are negligible in comparison to that with positive ions. The F_2 region collision frequency is found to be 7.6×10^6 sec^{-1}.

INTRODUCTION

The collision frequency of electrons with neutral and ionized gases of earth's atmosphere is well established. For the Martian atmosphere, it has neither been experimentally nor theoretically deduced. It is the purpose of the present paper to calculate these collison frequency in the Martian ionosphere.

THEORETICAL CONSIDERATIONS

The collision frequency of electrons with neutral gases depends on (a) the distribution of electron velocities, (b) the variation of electron collision cross-section for each gas with electron velocity and (c) the number densities of the neutral gases present Thus, collision frequency for mono-energetic electrons, ν_m is proportional to the electron-collision cross-section σ, the electron velocity v, and the density of each gas ρ, *i.e.*,

$$\nu_m = \sigma v \rho \qquad \ldots \quad (1)$$

where, σ is a complex function of v.

This expression can be rewritten in a simpler form according to Gerson (1961) :

$$\nu_m = 2\sigma N \left[\frac{(kT)}{3m}\right]^{\frac{1}{2}} \text{ sec}^{-1} \qquad \ldots \quad (2)$$

where, k is the Boltzmann's constant, T is the absolute temperature of the region under consideration, m is the mass of the electron and N is the number density of the gas with which the electrons collide.

The argument given above is strictly true only if the electron temperature and the gas temperature are the same. Otherwise, the collision frequency at each height should be increased by the ratio T_e/T_g, where T_e is the electron temperature and T_g is the gas temperature.

According to Nicolet (1953), the collision frequency of electrons with positive ions is given by

$$\nu_{ie} = \left[34+8.36 \log \frac{T_e^{3/2}}{N_e^{1/2}} \right] N_i \, . \, T^{-3/2} \quad \dots \quad (3)$$

where T is the absolute temperature of the region under consideration, N_e is the electron density and N_i is the positive ion density. The expression (3) is valid only if the electron temperature T_e is same as the ion temperature T_i If $T_e \neq T_i$, then one should adopt the following expression for ν_{ie} (Thrane & Piggott, 1966)

$$\nu_{ie} = [a+b \ln T_e(T_i/N_i)^{\frac{1}{2}}]N_i T_e^{-3/2} \quad \dots \quad (4)$$

where, a and b are constants.

Total collision frequency of the F_2 region is the sum of ν_m and ν_{ie} (Ramana & Rao, 1961) as the collision frequency of electrons with the negative ions is negligble, *i.e.*,

$$\nu = \nu_m+\nu_{ie} \quad \dots \quad (5)$$

3. Results and discussions

The F_2 region of the Martian ionosphere is at about 128 km high from its surface (Fjeldbo & Eshleman, 1968). For this region, the calculated values of the collison frequency of electrons with neutral and ionized gases are tabulated in table 1 In this calculation, it is asumed that $T_e = T_i = T_g$ and neutral particle concentrations in F_2 region are taken from Fjeldbo & Eshleman's paper (1968). The positive ion distribution has been taken from Agarwal's paper (1970). From table 1, it is apparent that νO, the collision frequency of

TABLE 1. Collision frequency of electrons with neutrals and Ions

Neutral gas	Collision frequency of electrons with neutral gas at 128 km	Ionized gas	Collision frequency of electrons with +ve ions at 128 km
CO_2	8.2×10^{-2}sec^{-1}	CO_2^+	3×10^{8}sec^{-1}
CO	8.6×10^{-1}sec^{-1}	CO^+	2.4×10^{8}sec^{-1}
O_2	2.5×10^{-7}sec^{-1}	O_2^+	1.2×10^{8}sec^{-1}
O	8.60 sec^{-1}	O^+	1.0×10^{8}sec^{-1}

electrons with oxygen atoms is larger than ν_{CO_2}, ν_{CO} and νO_2. However, in comparison to the collision frequency of electrons with positive ions νO is negligible and hence $\nu = \nu_i$. Among $\nu_{CO_2^+}$, ν_{CO^+}, ν_{O_2}, and ν_{O^+}, the $\nu_{CO_2^+}$ is the largest because of their largest number density in that region.

From table 1,

$$\nu = \nu_{CO_2^+} + \nu_{CO^+} + \nu_{O_2^+} + \nu_{O^+} = 7.6 \times 10^8 \text{ sec}^{-1}.$$

As no experimental values of ν are available, the calculated value could not be compared with them. It is proposed that ν should be determined also by experiments as it would be useful in framing a better theoretical model.

References

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